Physical scale modeling of tidal flow hydrodynamics at the port of Zeebrugge

Hassan Wael[1,2], Glen Heyvaert[1,2], and Marc Willems[2]

[1] Department of Civil Engineering, Ghent University, Technologiepark 904, B-9052 Zwijnaarde (Ghent), Belgium
E-mail: wnmhassan@gmail.com

[2] Flanders Hydraulics Research, Berchemlei 115, B-2140 Antwerp, Belgium
E-mail: marc.willems@mow.vlaanderen.be

The Belgian coast is exposed and highly affected by tidal variation in the North Sea which plays an important role on nearshore flow hydrodynamics and on different Belgian ports. The port of Zeebrugge is a major port at the Belgian coast with direct access to the sea and partially located nearshore with two large breakwaters. Due to the large tidal range (> 4m) the access channel and the port entrance are characterized by high cross currents at high water levels. A high flood current (> 2ms^{-1}) is generated at the entrance and safe navigation is not always secured. The mutual interaction between the fluctuating water level, oscillatory tidal currents, bed topography and the existing breakwaters creates temporal and spatial complex flow patterns in this area. Understanding tidal flow dynamics around the port entrance is primary important for the port accessibility (navigation) and the siltation in the outer port. This study is crucial for the port authority due to its direct effects on actual port activities and future development.

In an ongoing integrated research project several studies aim to determine the best solution to reduce tidal cross-currents; to evaluate the impact of the recommended design scenarios on the nautical accessibility and to identify the best method to minimize siltation in the outer port. The research methodology is based on using various engineering tools (numerical models, physical scale model) in combination with the existing field data to obtain the best results.

A physical model is a scaled representation of a hydraulic flow situation (i.e. tidal flow). Both the boundary conditions and the flow field must be scaled down in an appropriate way. Physical models are commonly used during design stages to optimize and select the best design scenario or to understand/explore certain processes. They have an important further role to assist non-engineering people during the 'decision-making' process. A hydraulic model may help the decision-makers to visualize and to picture the flow fields, before selecting the most 'suitable' design. The main use of physical models is (with controlled flow conditions) to study the behaviour of the prototype in the existing layout and in future plans. Physical model scale investigations require theoretical guidance derived primarily from the basic principles of fluid mechanics and the theory of similarity. Furthermore, physical models can provide data for improving numerical models of the complex flow.

A large physical scale model (2000m^2) was constructed at Flanders Hydraulics Research to study in depth this highly dynamic tidal region close to the port of Zeebrugge. The model was constructed with 1:300 horizontal and 1:100 vertical scales. The model was successfully calibrated (Willems *et al.*, 2014) using the existing prototype data. Various new design scenarios are investigated in the model (Hassan *et al.*, 2014). This publication will give a general overview of the research plan, physical model calibration, design scenarios, the capabilities of the physical model and the possible future modifications to improve the port accessibility.

References

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